Immersive Invasion of the Center of an *Earthquake*: Feel the monster breathing

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Introduction

We invite you to dare the sight and sounds of a growing earthquake-embryo, miles below the earth's crust. Get immersed, and watch the monster womb nurture one of the most dreaded threats of Mother Nature: earthquakes! This application presents recent results from immersive volume visualization of a large-scale earthquake simulation, spanning over four dimensions.

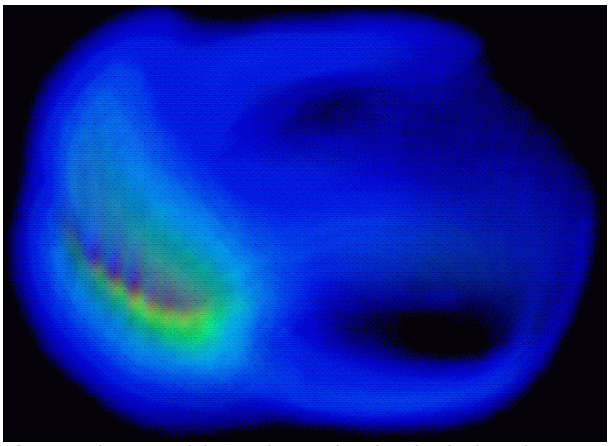


Fig 1. *A close-up of the 'embryo', showing the fault-region moments before the eruption of an earthquake.*

The simulation

This project is a collaborative effort between the University of California, Berkley, Carnegie Mellon University at Pittsburgh, and Mississippi State University. We describe a finite element formulation for modeling earthquake ground motion in sedimentary basins. The basin is modeled as a three-dimensional isotropic, heterogeneous anelastic medium. The domain is limited by absorbing boundaries that limit the amount and magnitude of spurious reflections.

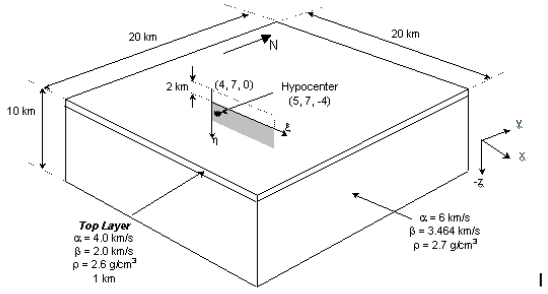
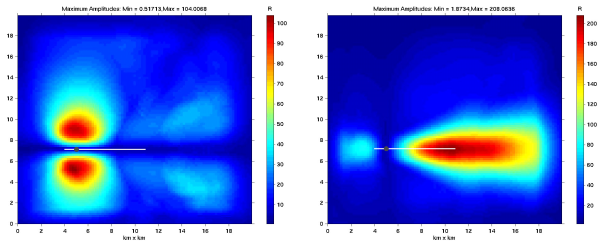


Fig 2. *Layered half space with extended source fault.*

This simulation is performed over the idealized model shown in Figure 2. The model incorporates an idealized extended strike-slip fault aligned with the coordinate system. The shaded area in Figure 2 represents such a fault. The computer analysis is performed on a Cray T3E parallel computer at the Pittsburgh Supercomputing Center. A total of 128 processors took almost 24 hours to calculate and store an 8 second velocity history of approximately 12 million-nodes arranged in a three-dimensional grid. The required amount of disk space for this problem was approximately 130 GB. The challenge was to develop methods for adequate visualization of such vast amount of data.

Preparing for the birth

Our first task was to extend the initial contour-based visualization method by adding both a spatial and a temporal domain to the rendering algorithm. To reduce the size-complexity of the raw simulation output, we first sampled its geometry into a regular rectilinear voxel-grid, taking care of the aliasing and super-sampling artifacts. This drastically reduced the size of the dataset from 14.16 GB to just 1.27 GB for the first 100 time steps. This compressed, node-indexed binary file format aided in achieving near-interactive frame rates for 3D texture-based volume visualization of the model.



(a) *Fault Parallel* (b) *Fault Normal Velocity*

Fig 3. *Maximum surface velocity contours for the model.*

Fly-around: Watch it breathe

Initial results of near-interactive volume visualization of the first few time steps (when the earthquake is still in its embryonic stages) have been exciting. They comply with the orthogonal response of the fault region of the simulation model. The later time steps show the eruption and the effects on the soil and the surface. Currently a desktop visualization system and a CAVE™ automated virtual environment are operational. The desktop application supports a fly-around the fault region where the embryo can be seen breathing in its womb, ready to erupt, which is a breath-taking sight! Immersion is expected to add additional cues (stereo, sound, walk-in, etc.) to nerve senses of the observers, which does not seem far-fetched now. The system will be demonstrated in a CAVE™ environment and also on an Immersive Workbench.

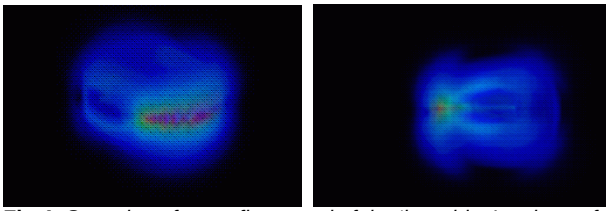


Fig 4. *Snapshots from a fly-around of the 'breathing' embryo of the earthquake.*

Ongoing and future work

We are creating an immersive time-based volume visualization of the scene in a virtual environment, with interactive simulation control. This is the next step into an ongoing large-scale simulation and visualization project, where we employ volume-rendering techniques to enable scientists and structural engineers to 're-live' the simulations. Can you dare to watch and listen to the seed of an earthquake, which might erupt any moment? If yes, visit us at http://www2.msstate.edu/~pc6/htm/spur.htm.

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